Name of Organization: Carnegie Mellon Research Institute

Type of Organization: College or University

Contact Information: Dr. Edwin Minkley

Environmental Technology Center

700 Technology Drive

Pittsburgh PA 15219

Phone: (412) 268 - 3188 **Extension:**

Fax: (412) 268 - 3101

E-Mail: minkley@andrew.cmu.edu

Project Title: In situ PCB Biodegradation & Mass Loss in Lake Erie Sediment

Project Category: Contaminated Sediments

Rank by Organization (if applicable): 2

Total Funding Requested ($): 103,646 **Project Duration:** 1 Years

Abstract:

The Carnegie Mellon Research Institute (CMRI) Environmental Technology Center proposes to apply PCB biodegradation monitoring tools that it has developed using sediments from two Great Lakes Areas of Concern to additional PCB contaminated sites in the Lake Erie region. Remedial scenarios for PCB contaminated sediments include: (1) selective sediment removal, (2) capping hot spots, (3) source control, (4) large-scale dredging, and (5) monitored natural attenuation (including sedimentation and biodegradation). In certain instances, an important component in the decision making process will be the fate of PCBs that are left in place in the sediments. Monitoring of in situ PCB biodegradation in contaminated sediments therefore becomes an important analytical component in the regulatory process. The bio-monitoring tools include: (1) computer analysis of PCB congener data from sediment cores using strategies developed at CMRI, (2) detailed congener specific analysis of biphenyl (BZ-0), 2-monochlorobiphenyl (BZ-1), the diortho-chlorobiphenyls (BZ-4, BZ-10) and the triortho-chlorobiphenyl (BZ19) as key indicators of PCB destruction, and (3) semi-quantitative analysis of the populations of PCB dechlorinating bacteria in field cores of PCB contaminated sediments. The main outcome of this project will be a guidance document that can be used to project the ultimate fate of PCBs, specifically mass loss, in Lake Erie sediments and thereby provide input to regulatory decisions.

Geographic Areas Affected by the Project

States:

- ☐ Illinois
- ☐ Indiana
- ☐ Michigan
- ☐ Minnesota
- ☒ New York
- ☒ Pennsylvania
- ☐ Wisconsin
- ☒ Ohio

Lakes:

- ☐ Superior
- ☐ Huron
- ☐ Michigan
- ☒ Erie
- ☐ Ontario
- ☐ All Lakes

Geographic Initiatives:

☐ Greater Chicago ☐ NE Ohio ☐ NW Indiana ☐ SE Michigan ☐ Lake St. Clair

Primary Affected Area of Concern: All AOCs

Other Affected Areas of Concern:

For Habitat Projects Only:

Primary Affected Biodiversity Investment Area:

Other Affected Biodiversity Investment Areas:

Problem Statement:

Sediments in the Lake Erie Areas of Concern are contaminated with polychlorinated biphenyls (PCBs), which are persistent bioaccumulative chemicals with a number of potential adverse health effects. Remedial scenarios for PCB contaminated sediments include: (1) selective sediment removal, (2) capping hot spots, (3) source control, (4) large-scale dredging, and (5) monitored natural attenuation (includes sedimentation and biodegradation). In certain instances, an important component in the decision making process will be the fate of PCBs which are left in place in the sediments.

Monitoring of in situ PCB biodegradation in contaminated sediments, therefore, becomes an important analytical component in the regulatory process. In the case of PCB contamination in the upper Hudson River, EPA Region II has expressed the opinion that natural attentuation via biodegradation is not a satisfactory remedial solution because: (1) microbially mediated PCB dechlorination does not occur reliably below a concentration of 30 ppm, and (2) ortho dechlorination (and therefore total PCB destruction) does not take place.

With respect to PCB contaminated sediments from the two Great Lakes Areas of Concern which we have studied, we have found that there are dramatically different processes taking place with respect to biodegradation. In the Grand Calumet River (Gary IN) sediments that we have studied, the Aroclor pattern in the sediments is essentially unchanged from that of the starting material, and laboratory tests showed the presence of little or no dechlorinating bacteria. In the Grasse River (Massena, NY) sediments, however, the PCBs show signs of extensive dechlorination, and dechlorinating bacteria are present. More importantly, in the Grasse River there is evidence that PCB dechlorination takes place at all PCB concentrations and that complete PCB destruction (mass loss) is occuring. Evidence for this latter point includes the presence of totally dechlorinated PCBs (i.e., biphenyl) and the presence of processes that degrade monochlorobiphenyls (BZ-1). There is also evidence of ortho dechlorination of PCBs. These results suggest very different potential fates for PCBs at these two different sites.

Proposed Work Outcome:

The Carnegie Mellon Research Institute (CMRI) Environmental Technology Center proposes to apply PCB biodegradation monitoring tools that it has developed during its previous work on river sediments to additional PCB contaminated sites in the Lake Erie Area of Concern. These additional sites will be selected in cooperation with personnel in the USEPA's Great Lakes National Program Office so as to maximize impact. The sites will be chosen so as to best demonstrate the potential of the new monitoring techniques that have been developed by CMRI as input for the regulatory decision making process. The bio-monitoring tools include: (1) computer analysis of PCB congener data from sediment cores using strategies developed at CMRI, (2)congener specific PCB analysis of biphenyl (BZ-0), 2-monochlorobiphenyl (BZ-1), and the

diortho-chlorobiphenyls (BZ-4, BZ-10) and the triortho-chlorobiphenyl (BZ-19) as key indicators of PCB destruction, and (3) semi-quantitative analysis of the populations of PCB dechlorinating bacteria in field cores of PCB contaminated sediments. The main outcome of this project will be a guidance document that can be used to project the ultimate fate of PCBs, specifically mass loss, in Lake Erie sediments and thereby provide input to regulatory decisions.

Computer Analysis of PCB Congener Data

Computer analysis of PCB congener data from field cores can indicate whether ortho dechlorination is taking place and whether there is a lower concentration limit on PCB dechlorination. Furthermore, the CMRI Biotechnology Group is in the process of developing methods for determining PCB dechlorination rates from the congener data from cores of PCB contaminated sediments. The approach we are using is analogous to that used in radioisotope dating methods.

These analyses will make use of existing PCB congener data that has been taken from Lake Erie sediment cores obtained by USEPA or the environmental regulatory agencies of one or more Great Lakes states. If necessary, it is assumed that USEPA will make available PCB congener data from other sediment cores of interest to this project.

Chemical Analysis of BZ-0, BZ-1, BZ-4, BZ-10 and BZ-19.

Typically, analysis of PCB sediments does not focus on those compounds that are the keys to monitoring of biological activity and the potential of complete biological destruction of PCBs. Therefore, the existing data sets will have serious gaps in terms of the computer analyses described above. The key compounds to be additionally analyzed include biphenyl (BZ-0), 2-monochlorobiphenyl (BZ-1), and separate determination of the diortho-chlorobiphenyls (BZ-4, BZ-10) and the triortho-chlorobiphenyl (BZ19). Biphenyl can be detected by GC-FID, with confirmation by MS; it is not determined in the standard GC-ECD analysis of PCBs. BZ-1 has a very low response factor for detection by electron capture, and should also be determined by GC-FID. BZ-4 and BZ-10 co-elute in many GC congener separation systems, and have very different ECD response factors. A separate GC run is needed to determine BZ-4 and BZ-10. This part of the project will encompass analyses for these key indicators of PCB biodegradation activity. The data will then be included in the computer analyses described above.

These analyses will make use of Lake Erie sediment cores provided by USEPA or the environmental regulatory agencies of one or more Great Lakes states, as described below. In some cases this may require additional sediment cores for data sets that are not part of the analysis of populations of PCB dechlorinating bacteria described below.

Analysis of PCB Dechlorinating Bacteria

CMRI will carry out semi-quantitative analysis of the populations of PCB dechlorinating bacteria in field cores of PCB contaminated sediments. An issue that can arise during analysis of sediment core data is whether PCB dechlorination is historic or ongoing. Analysis for the populations of PCB dechlorinating bacteria can help to resolve this issue since the continued presence of dechlorinating bacteria in field cores as a function of depth would indicate that PCB dechlorination is an ongoing process.

Other Issues

The CMRI Environmental Technology Center wishes to carry out site selection in cooperation with personnel from the USEPA's Great Lakes National Program Office. Based upon the outcome of these discussions, we will require the use of the R/V Lake Guardian and crew to obtain the desired sample cores. The CMRI Environmental Technology Center will also need the assistance of the USEPA's Great Lakes National Program Office in obtaining existing PCB congener data, as noted above. In some instances, this may also require obtaining additional sediment cores so as to be able to construct complete data sets for the computer analyses.

The tentative schedule for the R/V Lake Guardian shows that the vessel will be available to sample Lake Erie in mid-July and/or early August. CMRI-ETC would like to receive new core samples by late August 2000. In order for this schedule to be maintained, it will be necessary to have this grant awarded by July 1, 2000.

Project Milestones:	**Dates:**
Consult with GLNPO	07/2000
QAPP	08/2000
Field Sampling	08/2000
Obtain Existing Core Data	09/2000
Analytical Chemistry Results	12/2000
Dechlorination Test Results	04/2001
Computer Analysis	05/2001
Final Report	07/2001

☐ Project Addresses Environmental Justice

If So, Description of How:

☒ Project Addresses Education/Outreach

If So, Description of How:

The results of this program will be used to advise applicable state and federal regulatory agencies and also the Sediment Remediation/Contamination Work Groups throughout the Great Lakes Region. In addition, results will be disseminated through peer reviewed scientific publications.

Project Budget:

	Federal Share Requested ($)	Applicant's Share ($)
Personnel:	39,500	4,000
Fringe:	9,322	900
Travel:	2,000	0
Equipment:	0	0
Supplies:	6,000	0
Contracts:	10,000	0
Construction:	0	0
Other:	2,000	0
Total Direct Costs:	68,822	4,900
Indirect Costs:	34,824	2,479
Total:	103,646	7,379
Projected Income:	0	0

Funding by Other Organizations (Names, Amounts, Description of Commitments):

7.1% of the entire project costs will be provided in cash or in-kind contributions and other non-cash support from CMRI. For over seven years the CMRI Environmental Technology Center has been carrying out industry-sponsored research on PCB contaminated sediments in two Great Lakes Areas of Concern. Some of these results are available as the CMRI Final Report submitted in August 1999, by ALCOA, to USEPA, Region II, as part of a "Comprehensive Characterization of the Lower Grasse River." Subject to approval by the sponsors, the results of any contemporaneous studies can be made part of this project and would therefore constitute an additional in-kind matching contribution.

An $80,000 contract for work that supports the objectives of this proposed project is pending with one of our corporate sponsors (ALCOA).

Description of Collaboration/Community Based Support: